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ORIENTATION-ERROR ACCIDENTS IN REGULAR ARMY AIRCRAFT
DURING FISCAL YEAR 1970: RELATIVE INCIDENCE AND COST

Jorma I. Niven, W. Carroll Hixson, and Emil Spezia



ARMY - NAVY
Joint Report



U. S. ARMY AEROMEDICAL RESEARCH LABORATORY
NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY

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10 August 1973

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PENSACOLA, FLORIDA 32512

SUMMARY PAGE

THE PROBLEM

From the military mission viewpoint, the amount of research effort to be expended on the solution of a given aviation medicine problem must be keyed to the operational cost of the problem. Therefore, a necessary first step in the development of a solution is the assimilation of data that define the magnitude of the problem. Though orientation-error accidents involving pilot disorientation and vertigo have been long recognized to exist, little quantitative data are available to describe the actual incidence and cost of such accidents in Army aviation.

FINDINGS

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Agency for Aviation Safety, and the Naval Aerospace Medical Research Laboratory. The first step was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Regular Army flight operations beginning with fiscal year 1967. Findings are being summarized on a fiscal-year basis in three separate lines of reports: The first line is devoted to defining the over-all magnitude of the orientation-error problem in all aircraft types; the second line to the presentation of similar incidence and cost data for accidents involving only the UH-1 aircraft, the predominant rotary wing aircraft in the Army inventory; and the third line to the description of the various causal factors found to be present in the major UH-1 orientation-error accidents.

This specific report is the fourth in the series dealing with the over-all magnitude of the orientation-error problem in all aircraft types. Incidence and cost data are presented for all Regular Army major and minor orientation-error accidents detected in the search of the fiscal year 1970 accident files. Separate and totalized statistical data are provided for fixed wing and rotary wing aircraft as well as for accidents occurring in Vietnam and those occurring elsewhere.

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

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INTRODUCTION

To investigate the operational role of pilot disorientation and vertigo in the production of orientation-error type aircraft accidents, the authors have organized an inter-service research program under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory (USAARL), the U. S. Army Agency for Aviation Safety (USAAVS), and the Naval Aerospace Medical Research Laboratory (NAMRL). Since little quantified data were available to describe the actual magnitude of the orientation-error problem in Regular Army flight operations, the decision was made to conduct a five-year longitudinal study, beginning with fiscal year 1967, of all Army aircraft accidents that involved an erroneous judgment of aircraft motion or attitude on the part of the pilot. Two separate, but related, project objectives were set for the longitudinal study. The first was to extract and assimilate data from the USAAVS master aircraft-accident files which would define the actual and relative cost of orientation-error accidents to Regular Army flight operations. These data, by defining the operational magnitude of the problem, would then serve to define the extent of the research support which should be devoted to its solution. The second working objective was to extract data on a case-history basis which would describe the various pilot/aircraft/mission/environment factors found to be present in each of the orientation-error accidents. Assimilation and analysis of these data over the study period would result in better knowledge of the most common operational causes of orientation-error accidents and thus point out those research directions which offer the greatest potential toward the reduction of accident incidence.

The results of the longitudinal study are being summarized in three separate lines of reports, with one report in each line prepared for each fiscal year of the five-year study. The first line of reports (for example, ref. 1) is devoted to defining the incidence and cost of all major and minor orientation-error accidents involving all aircraft types, fixed wing as well as rotary wing, that occurred in Regular Army flight operations for each fiscal year. Since the UH-1 "Huey" helicopter has been, and is, the predominant aircraft in the Army rotary wing inventory, the second line of reports (for example, ref. 2) is devoted to defining the magnitude of the orientation-error accident problem in only this aircraft. The layout and format of this line of reports is almost identical to that of the first line. The third line of reports (for example, ref. 3) deals exclusively with the various causal factors found to be present in all of the major UH-1 orientation-error accidents. Typical data to be presented include phase of flight, time of day, type of mission, pilot experience, physiological factors, psychological factors, facility factors, environmental factors, and the like.

This specific report is the fourth in the series dealing with the magnitude of the orientation-error problem in all types of aircraft. Incidence and cost data are presented for all major and minor orientation-error accidents involving all Army Aviation flight operations, other than those of the Army National Guard or Army Aviation Reserve, that occurred during fiscal year 1970. In addition, corresponding cost data are presented for all accident types, regardless of cause, and for pilot-error accident types so as to better establish the relative magnitude of the orientation-error problem.

PROCEDURE

A basic requirement for the commencement of this study was a workable definition of the class of accidents to be defined as involving orientation error. The reader is referred to previous reports (1, 2, 3) for a comprehensive definition and discussion of its rationale. Briefly, orientation is considered to involve the correct determination of the dynamic position and attitude of an aircraft in three-dimensional space. The key word here is dynamic, which implies that full knowledge of the motion as well as static attitude and position is required to define its instantaneous spatial orientation. Accordingly, a pilot is considered to have made an orientation error whenever his perception of the motion and attitude of his aircraft differs from the true motion or altitude; i.e., the true orientation of the aircraft. An orientation-error accident is then defined as one that occurs as a result of an incorrect control or power action taken by a pilot (or a correct action not taken) due to his incorrect perception of the true orientation of his aircraft.

With this definition of orientation-error accidents serving as a classification reference, an experienced classifier read all briefs in the USAAVS master accident files and selected all major and minor accidents of this type occurring during fiscal year 1970. For redundancy, the entire accident files were also searched by sifting the coded summaries that USAAVS prepares for each accident for a wide range of indicator terms.

The authors then reviewed the accident briefs independently for the purpose of establishing whether or not an orientation-error accident classification would result. In addition, the comprehensive master file on each suspect accident was obtained and reviewed. Whenever there was serious question as to the contribution of orientation error to the accident or where equally weighted alternative causal factors were present, then the accident was not included in the classification. The net effect of this policy is to give a conservative estimate of the magnitude of the orientation-error accident problem.

RESULTS AND DISCUSSION

The reader is referred to the first report (1) of this series for details pertaining to the format selected to summarize the accident statistics on a fiscal year basis. Briefly, the format is keyed to providing a cursory review of the incidence and costs of aircraft accidents in general so as to place better perspective on the actual operational magnitude of the orientation-error accident problem. To establish this background, the first section to follow is devoted to describing the over-all cost of all Army Aviation aircraft accidents, regardless of type or location, that occurred during fiscal year 1970. In a second section, equivalent data in a nearly identical format are presented to separately identify those accidents in the first section that were classified by USAAVS as involving one or more pilot-error factors. Cost statistics pertaining to only orientation-error accidents are then presented in a third section. By using these three sets of data as independent references, it then becomes possible to establish some quantitative insight into the relative, as well as actual, cost of orientation-error accidents in Army Aviation flight operations. Selected comparative relationships of this type are presented in the last section of the report.

For convenience to the reader wishing to make a point-by-point comparison of the fiscal year 1970 accident statistics with the statistics for other fiscal years of the study, the layout and numbering of all tables and figures contained in this report follows identically that presented previously (1, 4, and 7).

ALL TYPES OF AIRCRAFT ACCIDENTS

The data presented in this section describe the incidence and cost of all major and minor aircraft accidents involving all Regular Army flight operations during fiscal year 1970. Separate data groupings are provided for accidents involving only fixed wing (FW) aircraft, only rotary wing (RW) aircraft, and their combined total. In addition, for each of these three statistical groupings, the data are divided into those accidents that occurred in Vietnam, those accidents that occurred elsewhere, and their combined total. Since the vast majority of the accidents that do not occur in Vietnam (VN) take place within the continental limits of the United States, the abbreviation US is arbitrarily used to denote all accidents which do not occur in Vietnam. It should be realized then that the US data grouping will include a small number of accidents which may have occurred, for example, in Europe, Africa, or elsewhere. A second point to be stressed is that the VN data pertain strictly to accidents, not losses due to enemy action.

In the interpretation of the accident statistics to follow, it becomes possible to compare FW and RW accident incidence or VN and US accident incidence only when some common measures of aircraft utilization are selected as weighting factors. To establish such comparative references, percent aircraft inventory, total flying hours, and total aircraft landings are used as basic weighting data in this report. These data, as well as the incidence and cost statistics presented in this section, are summarized in Tables I through IV. Table I pertains to all accidents in all types of aircraft, Table II to only FW accidents, and Table III to only RW accidents. The ratio of the RW data in Table III to the FW data in Table II is summarized in Table IV.

The aircraft inventory data listed in the fourth row of each of the tables indicates the following. First as shown by Table I, more aircraft operated out of US than out of VN. In relative terms 61.24 percent of the total FW and RW aircraft inventory were stationed in US as compared to only 38.76 percent in VN. The second point, derived from Tables II and III, is that RW aircraft remain the predominant aircraft in the aircraft inventory. Of the total number of aircraft, 81.94 percent were of the RW type and 18.06 percent of the FW type. For both types of aircraft, the VN/US inventory ratio was less than unity; i.e., 0.43 to 1 for FW and 0.69 to 1 for RW. Accordingly, in terms of average aircraft inventory, the majority of the aircraft operated in US and the majority of the aircraft were of the RW type. This is in correspondence with the inventory data of fiscal years 1967-1969.

The total aircraft flight hours data to be used as an accident weighting factor are plotted in Figure 1A for both aircraft types and for both geographical references. The visual interpretation of this graph, as well as the majority of the remaining graphs in the report, is as follows: The group of three bars drawn at the left in Figure 1A pertains to the total flying hours of all FW aircraft. Within this three-bar group, the right-hand bar,

TABLE I				
FISCAL YEAR 1970 DATA				
ALL ACCIDENT TYPES		ALL AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	231	784	1,015	3.39
Minor Accidents	24	18	42	0.75
Total Accidents	255	802	1,057	3.15
Aircraft Inventory - Percent Total	61.24	38.76	100.00	0.63
Total Flying Hours	2,721,946	3,551,300	6,273,246	1.31
Total Landings	9,451,842	9,413,590	18,865,432	1.00
Major Accidents per 100,000 Hours	8.49	22.08	16.18	2.60
Minor Accidents per 100,000 Hours	0.88	0.51	0.67	0.58
Total Accidents per 100,000 Hours	9.37	22.58	16.85	2.41
Major Accidents per 100,000 Landings	2.44	8.33	5.38	3.41
Minor Accidents per 100,000 Landings	0.25	0.19	0.22	0.75
Total Accidents per 100,000 Landings	2.70	8.52	5.60	3.16
Total Dollar Cost	18,491,652	138,250,979	156,742,631	7.48
Average Dollar Cost per Accident	72,516.28	172,382.77	148,290.10	2.38
Total Fatalities	56	462	518	8.25
Average Fatalities per Accident	0.22	0.58	0.49	2.62
Fatal Accidents - Number	29	147	176	5.07
Fatal Accidents - Percent	11.37	18.33	16.65	1.61
Average Fatalities per Fatal Accident	1.93	3.14	2.94	1.63
Total Nonfatal Injuries	128	991	1,119	7.74
Average Nonfatal Injuries per Accident	0.50	1.24	1.06	2.46

TABLE II
FISCAL YEAR 1970 DATA

ALL ACCIDENT TYPES		FIXED WING AIRCRAFT ONLY		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	44	58	102	1.32
Minor Accidents	12	1	13	0.08
Total Accidents	56	59	115	1.05
Aircraft Inventory - Percent Total	12.66	5.40	18.06	0.43
Total Flying Hours	549,574	456,527	1,006,101	0.83
Total Landings	1,044,238	401,786	1,446,024	0.39
Major Accidents per 100,000 Hours	8.01	12.71	10.14	1.59
Minor Accidents per 100,000 Hours	2.18	0.22	1.29	0.10
Total Accidents per 100,000 Hours	10.19	12.92	11.43	1.27
Major Accidents per 100,000 Landings	4.21	14.44	7.05	3.43
Minor Accidents per 100,000 Landings	1.15	0.25	0.90	0.22
Total Accidents per 100,000 Landings	5.36	14.69	7.95	2.74
Total Dollar Cost	2,908,437	8,213,999	11,122,436	2.83
Average Dollar Cost per Accident	51,936.38	139,220.32	96,716.84	2.68
Total Fatalities	9	15	24	1.67
Average Fatalities per Accident	0.16	0.26	0.21	1.58
Fatal Accidents - Number	4	8	12	2.00
Fatal Accidents - Percent	7.14	13.56	10.44	1.90
Average Fatalities per Fatal Accident	2.25	1.88	2.00	0.83
Total Nonfatal Injuries	18	26	44	1.45
Average Nonfatal Injuries per Accident	0.32	0.44	0.38	1.37

TABLE III
FISCAL YEAR 1970 DATA

ALL ACCIDENT TYPES		ROTARY WING AIRCRAFT ONLY		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	187	726	913	3.88
Minor Accidents	12	17	29	1.42
Total Accidents	199	743	942	3.73
Aircraft Inventory - Percent Total	48.58	33.36	81.94	0.69
Total Flying Hours	2,172,372	3,094,773	5,267,145	1.43
Total Landings	8,407,604	9,011,804	17,419,408	1.07
Major Accidents per 100,000 Hours	8.61	23.46	17.33	2.73
Minor Accidents per 100,000 Hours	0.55	0.55	0.55	1.00
Total Accidents per 100,000 Hours	9.16	24.01	17.89	2.62
Major Accidents per 100,000 Landings	2.23	8.06	5.24	3.62
Minor Accidents per 100,000 Landings	0.14	0.19	0.17	1.32
Total Accidents per 100,000 Landings	2.37	8.25	5.41	3.48
Total Dollar Cost	5,583,215	130,036,980	145,620,195	8.35
Average Dollar Cost per Accident	78,307.61	175,016.12	154,586.20	2.24
Total Fatalities	47	447	494	9.51
Average Fatalities per Accident	0.24	0.60	0.53	2.55
Fatal Accidents - Number	25	139	164	5.56
Fatal Accidents - Percent	12.56	18.71	17.41	1.49
Average Fatalities per Fatal Accident	1.88	3.22	3.01	1.71
Total Nonfatal Injuries	110	965	1,075	8.77
Average Nonfatal Injuries per Accident	0.55	1.30	1.14	2.35

TABLE IV
FISCAL YEAR 1970 DATA

ALL ACCIDENT TYPES		RATIO OF RW TO FW DATA	
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	4.25	12.52	8.95
Minor Accidents	1.00	17.00	2.23
Total Accidents	3.55	12.59	8.19
Aircraft Inventory - Percent Total	3.84	6.18	4.54
Total Flying Hours	3.95	6.78	5.24
Total Landings	8.05	22.43	12.05
Major Accidents per 100,000 Hours	1.08	1.85	1.71
Minor Accidents per 100,000 Hours	0.25	2.51	0.43
Total Accidents per 100,000 Hours	0.90	1.86	1.57
Major Accidents per 100,000 Landings	0.53	0.56	0.74
Minor Accidents per 100,000 Landings	0.13	0.76	0.19
Total Accidents per 100,000 Landings	0.44	0.56	0.68
Total Dollar Cost	5.36	15.83	13.09
Average Dollar Cost per Accident	1.51	1.26	1.60
Total Fatalities	5.22	29.80	20.58
Average Fatalities per Accident	1.47	2.37	2.51
Fatal Accidents - Number	6.25	17.38	13.67
Fatal Accidents - Percent	1.76	1.38	1.67
Average Fatalities per Fatal Accident	0.84	1.72	1.51
Total Nonfatal Injuries	6.11	37.12	24.43
Average Nonfatal Injuries per Accident	1.72	2.95	2.98

marked VN, plots the total number of FW hours flown in Vietnam; the left-hand bar, marked US, plots the total number of hours flown elsewhere (primarily in the United States); and the central bar of this group, marked ALL, is a plot of the direct sum of the adjacent VN and US data. The interpretation of the three-bar group drawn at the right in Figure 1A follows identically except that total hours of RW aircraft are involved. Similarly, the three-bar group at the center of the figure describes the total hours of both types of aircraft with the depicted data representing the direct sum of the adjacent FW and RW data.

The data of Figure 1A and Table I show that for fiscal year 1970, 3,551,300 hours were flown in VN as compared to 2,721,946 hours flown elsewhere. This results in a VN/US total hours ratio of 1.31 indicating increasing relative as well as actual usage in Vietnam. This is in contradistinction to the fiscal year 1967 findings which showed greater flight time in US and 1968-1969 findings showing a trend to VN dominance. The total hours data of Tables II and III show that for FW aircraft, the VN/US total hours ratio was 0.83 to 1 indicating a greater usage in the US. However, the 1.43 to 1 VN/US total hours ratio for RW aircraft indicates the opposite. It should be observed also that on the average, the total number of hours flown in RW aircraft was slightly greater than that flown in FW aircraft even allowing for the fact that the RW inventory was greater than the FW inventory. That is, the RW/FW flying hours ratio was 5.24 to 1 while the RW/FW inventory ratio was 4.54 to 1 (see Table IV).

Weighting-factor data with total aircraft landings as reference are plotted in Figure 1B. In terms of landings, aircraft utilization was the same in the US as in VN resulting in a VN/US total landings ratio of 1.00 to 1. For FW aircraft, the VN/US total landings ratio dropped to 0.39 to 1 indicating considerably greater US utilization. However, for RW aircraft, this ratio rose to 1.07 to 1 indicating that the total number of landings in US and VN were approximately equal.

With these aircraft utilization data serving as reference, it becomes possible to make a weighted interpretation of the raw accident data presented in Tables I through IV. The numerical incidence of all major and minor accidents, regardless of type or causal factor, is plotted in Figure 2. The cost of these accidents, as measured by the total number of fatal accidents, number of fatalities, number of nonfatal injuries, and aircraft dollar damage is outlined in Figures 3A through 3D, respectively.

In terms of the over-all aircraft accident problem, these data show that during fiscal year 1970, there were a total of 1,057 accidents, 176 of which were fatal; there resulted 518 fatalities, 1,119 nonfatal injuries, and a total aircraft damage cost of \$156,742,631. The FW aircraft contribution to these totals was 115 accidents (12 of which were fatal), resulting in 24 fatalities, 44 nonfatal injuries, and a total aircraft damage cost of \$11,122,436. The RW data show 942 accidents (164 of which were fatal), resulting in 494 fatalities, 1,075 nonfatal injuries, and a total aircraft damage cost of \$145,620,195. For FW aircraft, accident incidence in VN was 1.05 times the US incidence. For RW aircraft, accident incidence in VN was 3.73 times the US incidence.

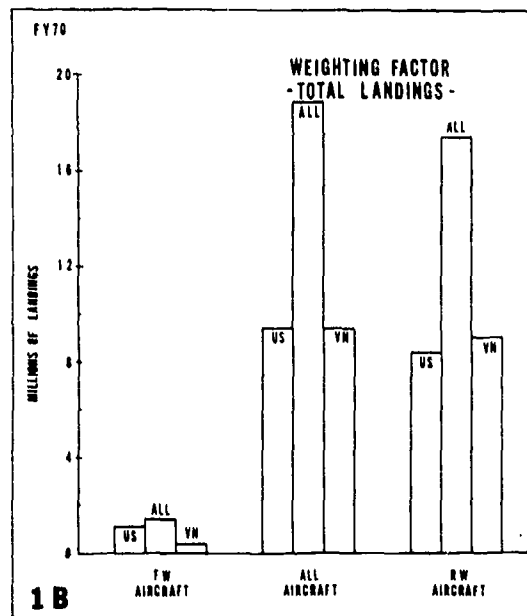
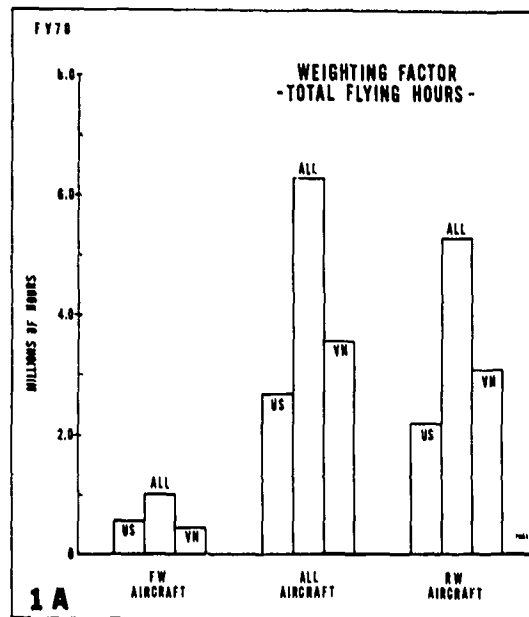


Figure 1

Total flying hours (A) and total landings (B) by aircraft type and location during fiscal year 1970. In A, the three bars at the left pertain to fixed wing (FW) aircraft with the VN bar indicating total FW hours flown in Vietnam; the US bar total hours flown elsewhere (primarily in the United States); and the ALL bar the sum of the adjacent VN/US data. The layout of the three bars at the extreme right is identical, but pertains to rotary wing (RW) aircraft hours. The three central bars summarize the FW and RW data and represent total hours of all aircraft types. Total RW hours were 5.24 times the total FW hours while total RW landings were 12.05 times the total FW landings. Considering all aircraft, aircraft utilization in VN was somewhat higher in terms of hours flown and the same in terms of landings as compared to US; i.e., the VN/US total hours ratio was 1.31 to 1 and the VN/US total landings ratio was 1.00 to 1.

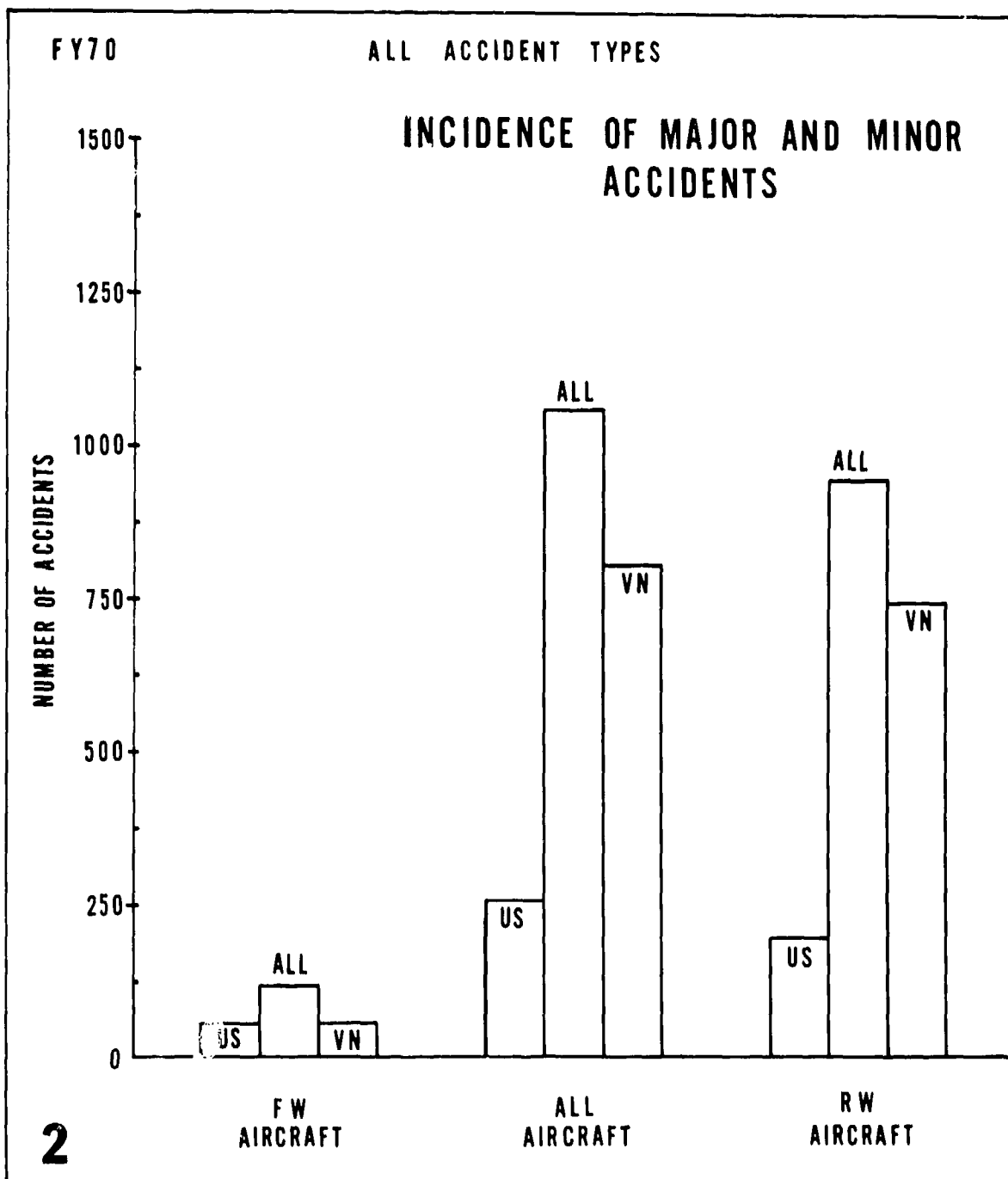


Figure 2

All Accident Types: Total number of major and minor aircraft accidents of all types that occurred in Regular Army flight operations during fiscal year 1970. Total number of FW accidents is shown by the center bar at the left, with the adjacent VN and US bars indicating location of the accidents. Data for RW accidents are at the extreme right, with total accidents of both aircraft types summarized in the center. The VN data presented throughout this report pertain to aircraft accidents, not losses due to enemy action, that occurred in Vietnam. Considering all aircraft, the incidence of accidents in VN was 3.15 times greater than the incidence elsewhere.

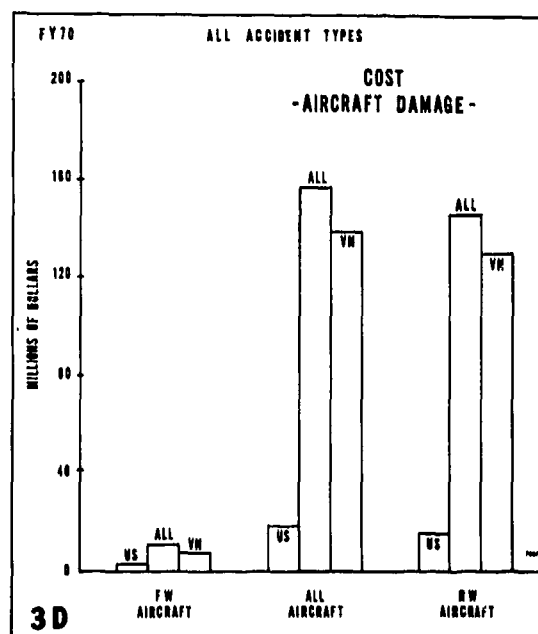
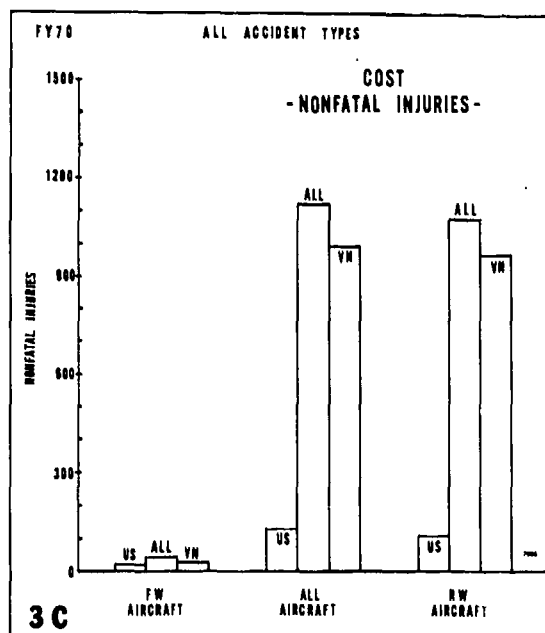
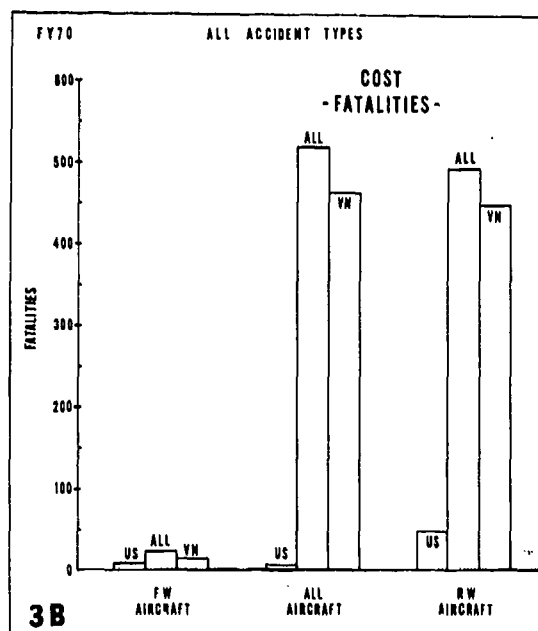
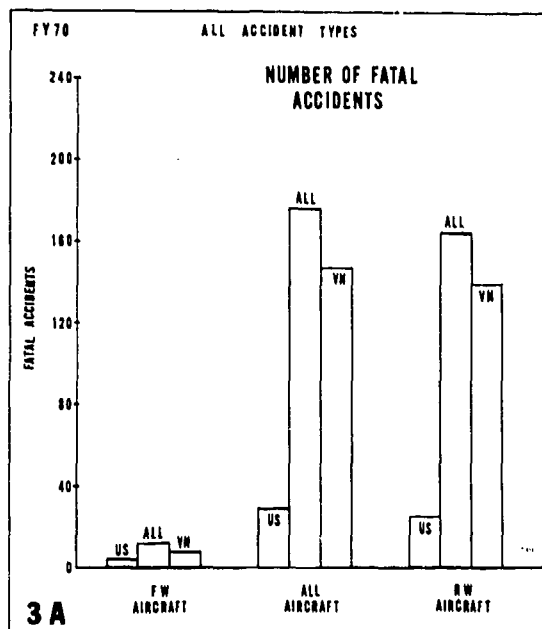


Figure 3

All Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both RW and FW aircraft and for both VN and US locations. For RW aircraft, the loss was always greatest in VN.

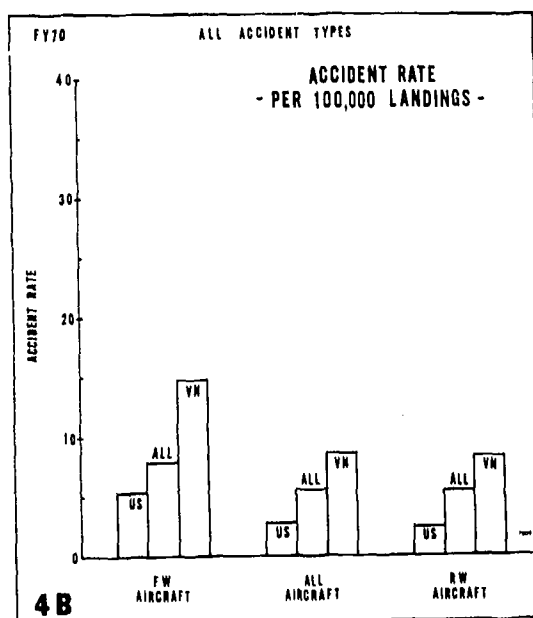
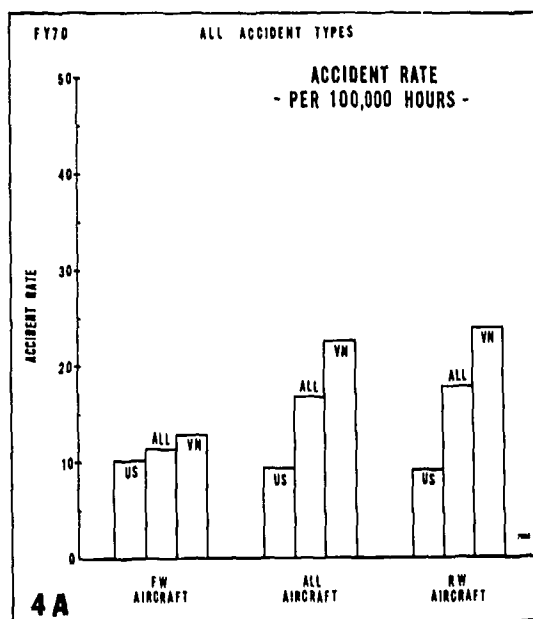


Figure 4

All Accident Types: Normalized incidence data showing average number of accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). For all FW aircraft, the rates were 11.43 and 7.95 accidents per 100,000 hours and per 100,000 landings, respectively. For all RW aircraft, the rates were 17.89 and 5.41 accidents per 100,000 hours and per 100,000 landings, respectively.

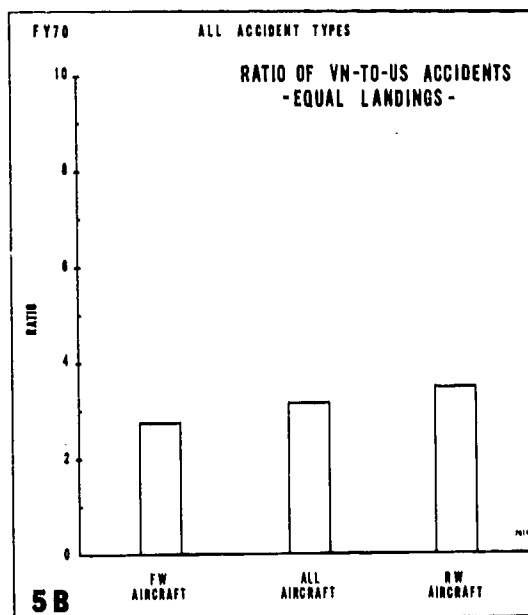
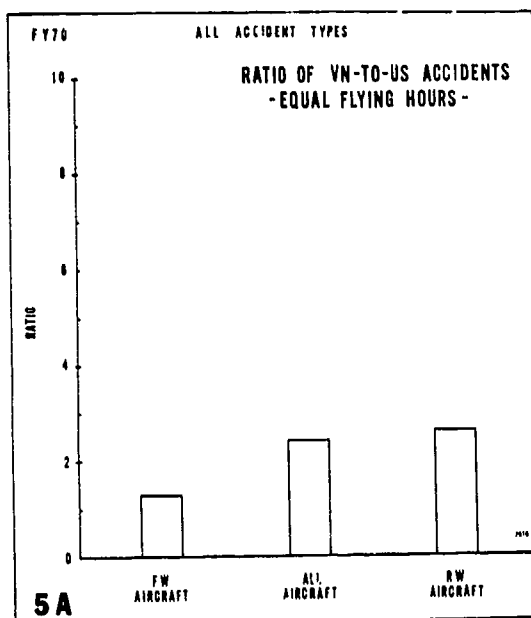


Figure 5

All Accident Types: Normalized ratio of accidents occurring in VN to accidents occurring in US based on equal flying hours (A) and equal landings (B) for both types of aircraft. Based on equal hours, the accident rates in VN for FW and RW aircraft were 1.27 and 2.62 times as great, respectively, as the US rates. Based on equal landings, the accident rates in VN for FW and RW aircraft were 2.74 and 3.48 times as great, respectively, as the US rates.

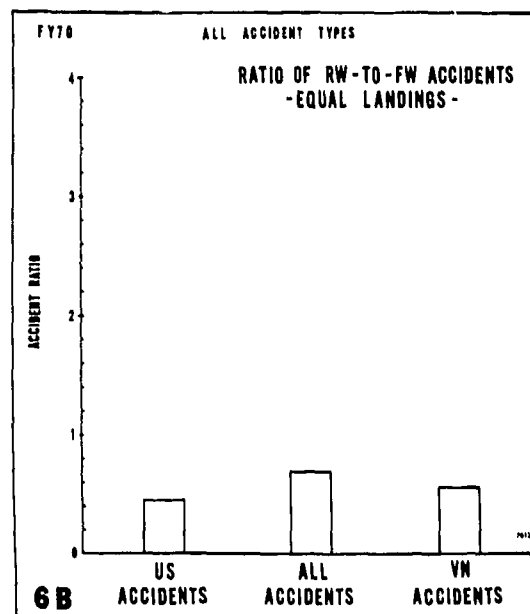
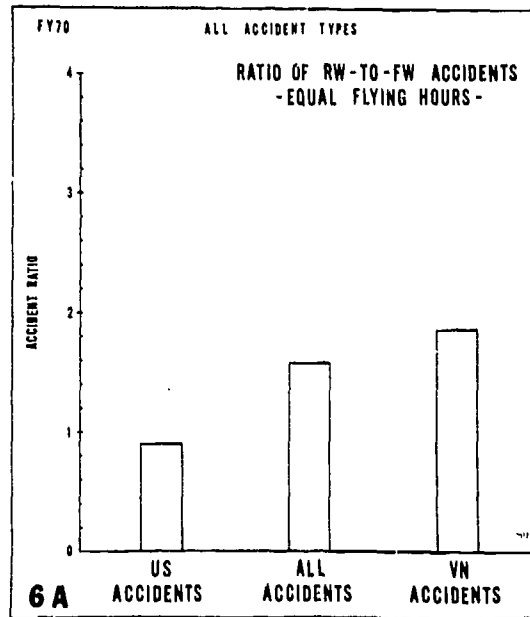


Figure 6

All Accident Types: Normalized ratio of accidents occurring in RW aircraft to accidents occurring in FW aircraft based on equal flying hours (A) and equal landings (B) for both locations. When equal hours served as a reference (A), the probability of an accident occurring in the US was about the same for both aircraft types. In VN, the RW accident rate was 1.86 times as great as the FW accident rate. When equal landings were used as a reference (B) the probability of an accident occurring in a RW aircraft was less than that for FW aircraft for either location.

The Table I data show also that the cost of these VN accidents was considerable in terms of personnel and aircraft. That is, there were 5.07 times as many fatal accidents in VN as there were elsewhere, 8.25 times as many fatalities, and 7.74 times as many nonfatal injuries. In addition, the average dollar cost of a VN accident was 2.38 times the cost of a US accident. In terms of total dollar damage to the accident aircraft, the VN cost was 7.48 times the US cost. These fiscal year 1970 findings support the fiscal year 1967-1969 data with regard to establishing the significantly greater accident incidence and accident costs associated with the stresses of a combat oriented environment.

To facilitate the comparison of these fiscal year 1970 data with accident incidence data to be presented for subsequent years, the data sets in Figure 2 have been normalized relative to the total number of flying hours flown by each type of aircraft in both locales and plotted in Figure 4A as the average number of accidents occurring every 100,000 hours. The same normalization with total landings as reference was accomplished for Figure 4B which shows the accident rate for every 100,000 landings. The VN/US ratio of these rate data for both aircraft types are plotted in Figure 5. Considering only FW aircraft, the VN accident rates increased relative to the US rate (1.27 to 1) when total hours served as reference. When total landings are considered the FW accident rate in VN was 2.74 times greater than the US rate. For RW aircraft, the VN accident rate was greater than the US rate for either weighting reference; i.e., the VN accident rate was 2.62 times the US rate based on hours and 3.48 times the US rate based on landings. For this fiscal year, the cost of the combat-oriented VN environment in terms of accident incidence was greater for RW aircraft.

To show the relationship between accident incidence in RW aircraft and that in FW aircraft, the ratio of the RW to FW accident rate data presented in Figure 5 is plotted for the two locations in Figure 6. These data are also listed in Table IV. The RW/FW accident ratio for US operations, based on equal hours was 0.90 to 1 indicating that the probability of an accident tending to be less for RW aircraft. The same ratio for VN operations was 1.86 to 1 indicating a greater risk in RW aircraft. When landings are used as reference, however, the RW/FW accident ratio drops to 0.44 to 1 for US operations and 0.56 to 1 for VN operations indicating a greater risk in FW aircraft.

PILOT-ERROR ACCIDENTS

In this section, incidence and cost data are presented for all accidents that were classified by USAAVS as involving one or more pilot-error causal factors. It should be observed that this classification does not imply that pilot error was the only, or even the primary, accident causal factor. That is, this grouping includes all accidents involving one or more pilot errors even though, for example, material failure, maintenance shortcomings, or poor facilities may also have contributed to the cause of the accident. A further point, by definition, is that these pilot-error accidents are a subgroup of the all-accident statistics discussed in the previous section.

Incidence and cost data for these fiscal year 1970 pilot-error accidents are presented in Tables V through VIII, with the Table V data pertaining to accidents in all types of

TABLE V FISCAL YEAR 1970 DATA				
PILOT-ERROR ACCIDENTS ONLY		ALL AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	191	583	774	3.05
Minor Accidents	18	13	31	0.72
Total Accidents	209	596	805	2.85
Total Dollar Cost	15,976,590	102,315,777	118,292,367	6.41
Average Dollar Cost per Accident	76,443.02	171,670.77	146,947.04	2.25
Total Fatalities	49	364	413	7.43
Average Fatalities per Accident	0.24	0.61	0.51	2.61
Fatal Accidents - Number	25	119	144	4.76
Fatal Accidents - Percent	11.96	19.97	17.89	1.67
Average Fatalities per Fatal Accident	1.96	3.06	2.87	1.56
Total Nonfatal Injuries	111	745	856	6.71
Average Nonfatal Injuries per Accident	0.53	1.25	1.06	2.35

TABLE VI FISCAL YEAR 1970 DATA				
PILOT-ERROR ACCIDENTS ONLY		FIXED WING AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	37	50	87	1.35
Minor Accidents	9	1	10	0.11
Total Accidents	46	51	97	1.11
Total Dollar Cost	2,350,747	7,273,311	9,624,058	3.10
Average Dollar Cost per Accident	51,103.20	142,613.94	99,217.09	2.79
Total Fatalities	9	15	24	1.67
Average Fatalities per Accident	0.20	0.30	0.25	1.50
Fatal Accidents - Number	4	8	12	2.00
Fatal Accidents - Percent	8.70	15.69	12.37	1.80
Average Fatalities per Fatal Accident	2.25	1.88	2.00	0.83
Total Nonfatal Injuries	16	23	39	1.44
Average Nonfatal Injuries per Accident	0.35	0.45	0.40	1.30

TABLE VII FISCAL YEAR 1970 DATA				
PILOT-ERROR ACCIDENTS ONLY		ROTARY WING AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	154	533	687	3.46
Minor Accidents	9	12	21	1.33
Total Accidents	163	545	708	3.34
Total Dollar Cost	13,625,843	95,042,466	108,668,309	6.98
Average Dollar Cost per Accident	83,594.13	174,389.85	153,486.31	2.09
Total Fatalities	40	349	389	8.73
Average Fatalities per Accident	0.25	0.64	0.55	2.61
Fatal Accidents - Number	21	111	132	5.29
Fatal Accidents - Percent	12.88	20.37	18.55	1.58
Average Fatalities per Fatal Accident	1.91	3.15	2.95	1.65
Total Nonfatal Injuries	95	722	817	7.60
Average Nonfatal Injuries per Accident	0.58	1.33	1.15	2.27

TABLE VIII FISCAL YEAR 1970 DATA			
PILOT-ERROR ACCIDENTS ONLY		RATIO OF RW TO FW DATA	
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	4.16	10.66	7.90
Minor Accidents	1.00	12.00	2.10
Total Accidents	3.54	10.69	7.30
Total Dollar Cost	5.80	13.07	11.29
Average Dollar Cost per Accident	1.64	1.22	1.55
Total Fatalities	4.45	23.27	16.21
Average Fatalities per Accident	1.26	2.18	2.22
Fatal Accidents - Number	5.25	13.88	11.00
Fatal Accidents - Percent	1.48	1.30	1.51
Average Fatalities per Fatal Accident	0.85	1.68	1.47
Total Nonfatal Injuries	5.94	31.39	20.95
Average Nonfatal Injuries per Accident	1.68	2.94	2.87

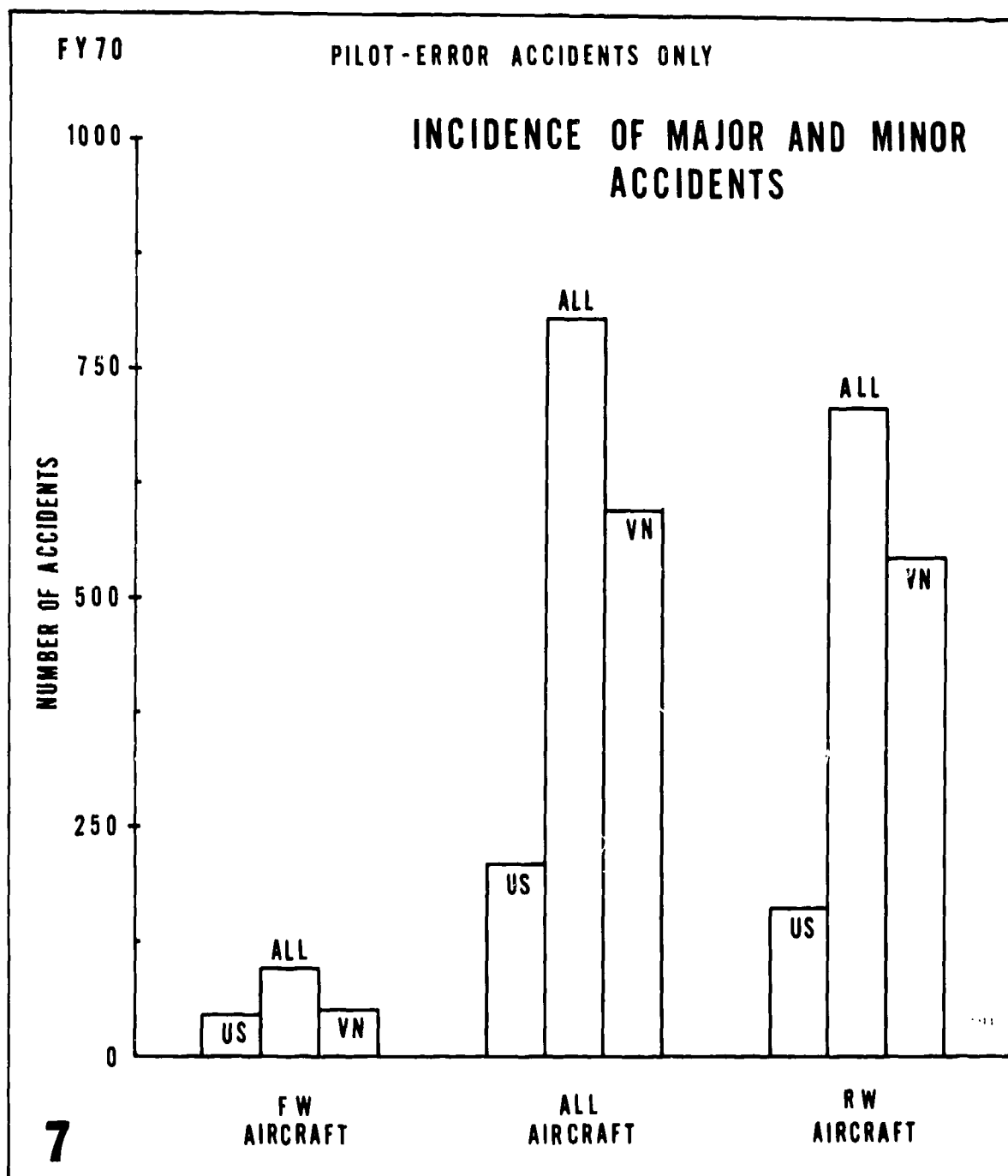


Figure 7

Pilot-Error Accident Types: Total number of major and minor accidents that were classified by USAAAVS as involving one or more pilot-error factors. As with the Figure 2 "All Accident Type" incidence data, the number of pilot-error accidents occurring in RW aircraft operating out of VN considerably exceeded those occurring elsewhere. However, for FW aircraft, the number of pilot-error accidents that occurred in VN was only slightly more than the US total. Considering all aircraft, the VN incidence was 2.85 times greater than the US incidence.

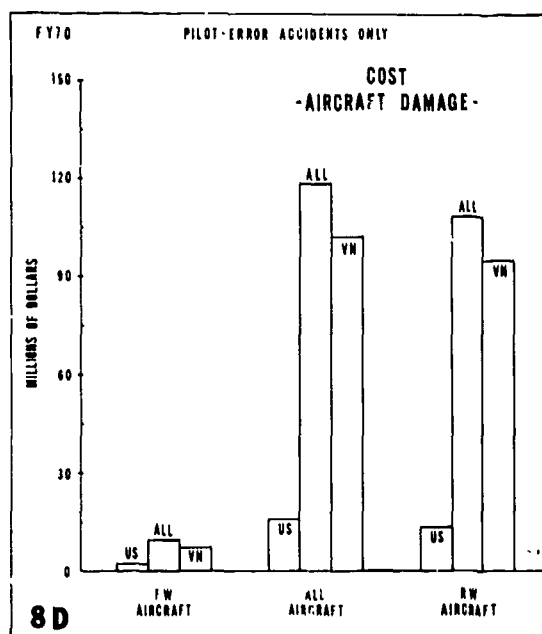
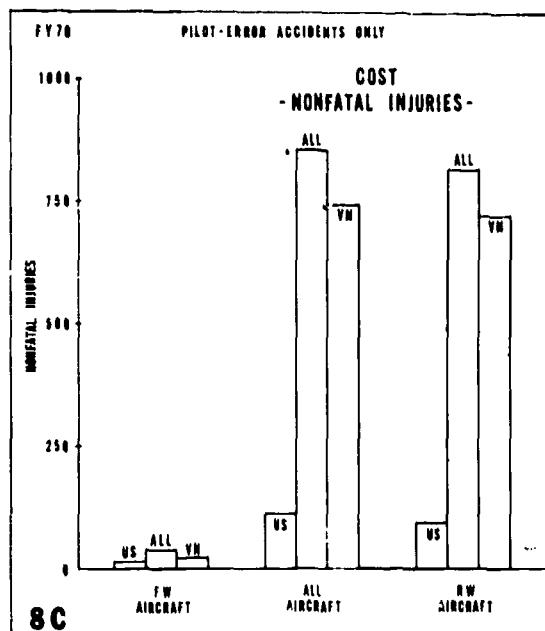
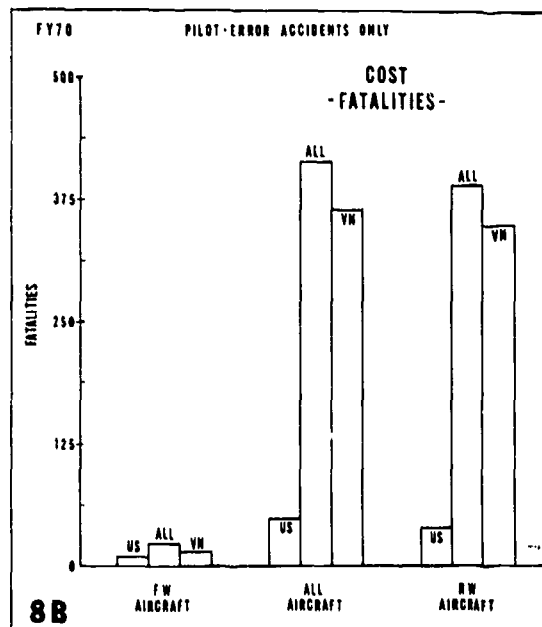
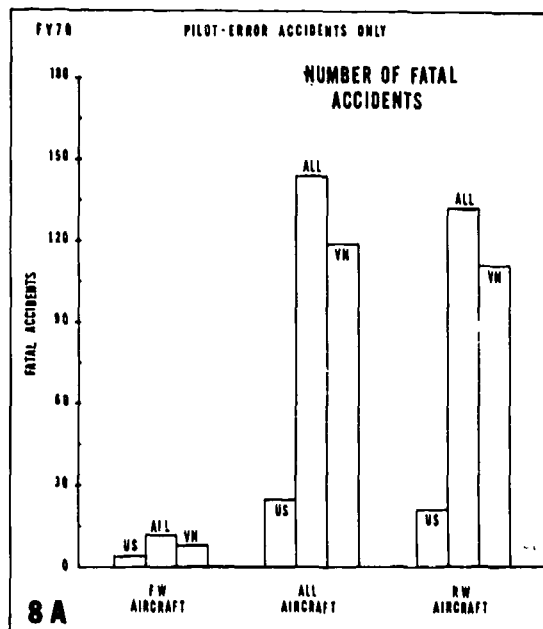


Figure 8

Pilot-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations. For RW aircraft, the loss was always much greater in VN.

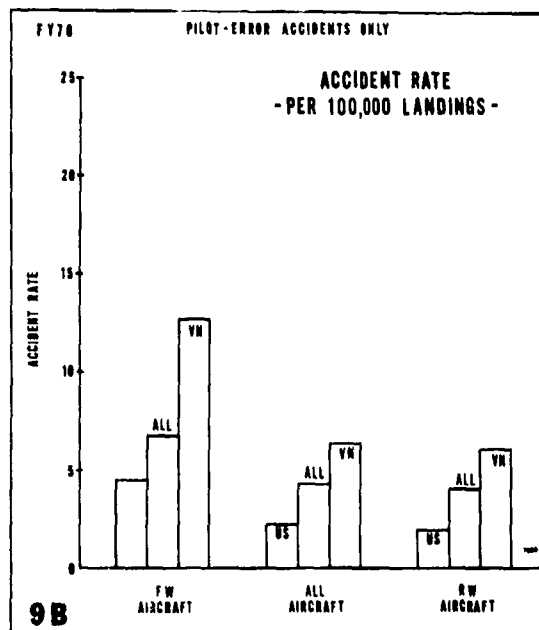
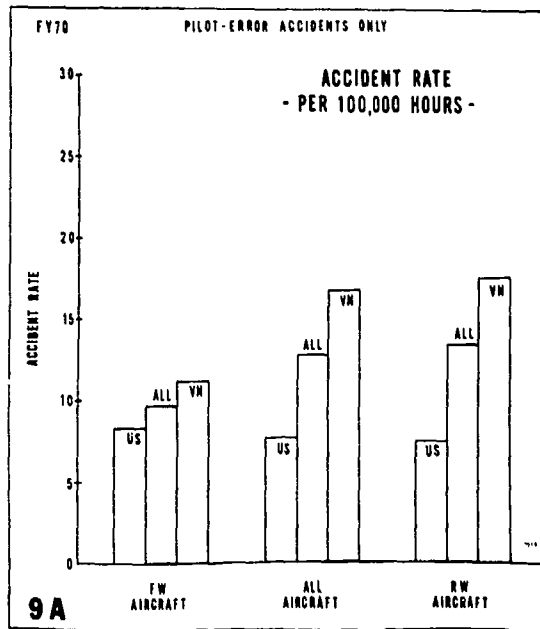


Figure 9

Pilot-Error Accident Types: Normalized incidence data showing average number of pilot-error accidents per 100,000 flying hours (A) and average number of pilot-error accidents per 100,000 landings (B). These rate data are intended only as a fiscal year 1970 baseline reference for comparison with similar data calculated for other fiscal years of the longitudinal study. For FW aircraft, the over-all rates were 9.64 and 6.71 accidents per 100,000 hours and per 100,000 landings, respectively. For RW aircraft, the over-all rates were 13.44 and 4.07 accidents per 100,000 hours and per 100,000 landings, respectively.

aircraft, the Table VI data to only FW accidents, the Table VII data to only RW accidents, and the Table VIII data describing the ratio of the RW to FW data presented in Tables VII and VI, respectively. Selected incidence and cost data are depicted in Figures 7 and 8. Normalized accident rate data, based on the total hours and total landings data of Figure 1, are plotted in Figure 9. These rate data, as with the rate data of Figure 4, are intended primarily as a baseline reference for comparison with similar data presented for other fiscal years of the study.

The incidence data of Figure 7 show that there was a total of 805 major and minor accidents involving pilot error; of this total, 144 were fatal accidents. The over-all cost was 413 fatalities, 856 nonfatal injuries, and \$118,292,367 aircraft damage. The FW contribution to this total was 97 accidents (12 of which were fatal), resulting in 24 fatalities, 39 nonfatal injuries, and \$7,624,058 aircraft damage. For RW aircraft, there were 708 accidents (132 of which were fatal), resulting in 389 fatalities, 817 nonfatal injuries, and \$108,668,309 aircraft damage. For RW aircraft, the incidence of pilot-error accidents was 3.34 times greater in VN than in the US. For FW aircraft, however, the incidence in VN was only slightly more than that in the US.

As with the all-accident data, the cost of RW pilot-error accidents in terms of personnel and aircraft damage was greater in VN. As calculated in Table VII and depicted in Figure 8, there were 5.29 times as many fatal RW accidents in VN as there were elsewhere, 8.73 times as many fatalities, and 7.60 times as many nonfatal injuries. In addition, the average cost of a RW pilot-error accidents in VN was 2.09 times the US average. In terms of total RW aircraft damage, the VN cost was 6.98 times greater than the US cost. In general, for the FW pilot-error accidents, the corresponding VN/US cost ratios were considerably lower.

The accident rate data presented in Figure 9 also establishes the higher cost of VN operations. For FW aircraft, the over-all accident rates were 9.64 and 6.71 accidents per 100,000 hours and per 100,000 landings, respectively. The VN rate was 1.34 times the US rate based on equal hours and 2.88 times the US rate based on equal landings. For RW aircraft, the over-all rates were 13.44 and 4.07 accidents per 100,000 hours and per 100,000 landings, respectively. The VN rate was 2.35 times the US rate based on hours and 3.12 times the US rate based on landings.

ORIENTATION-ERROR ACCIDENTS ONLY

This section summarizes the incidence and cost of all orientation-error type accidents detected in our review of the USAAVS accident files. As detailed with selected qualifications in the procedure section of this report, this listing includes all accidents arising from an incorrect control or power action taken by a pilot due to his incorrect perception of the true motion or altitude of his aircraft. The reader should recognize that the orientation-error accidents discussed herein are a subgroup of the pilot-error accident statistics presented in the previous section.

The main elements of the orientation-error statistics are summarized in Tables IX through XII, with the Table IX data pertaining to accidents in all types of aircraft, the Table X data to only FW accidents, the Table XI data to only RW accidents, and the Table XII data describing the ratio of the RW to FW data presented in Tables XI and X, respectively. The pertinent incidence and cost data are outlined in Figures 10 and 11. Normalized accident rate data for these accidents are presented in Figure 12 for comparison of incidence in other fiscal years of the longitudinal study.

These data show that there were a total of 81 major and minor orientation-error accidents (25 of which were fatal), resulting in 80 fatalities, 104 nonfatal injuries, and an aircraft damage cost of \$19,355,689. The FW contribution was relatively small involving a total of only six accidents (1 of which was fatal), 1 fatality, 6 nonfatal injuries, and a total dollar cost of \$2,295,199. It is obvious that with such a low incidence (n) for fiscal year 1970 FW orientation-error accidents, conclusion to be drawn as to RW/FW or US/VN accident incidence and cost must await the acquisition of further FW data in this longitudinal study. For RW aircraft, there were a total of 75 major and minor orientation-error accidents (24 of which were fatal), resulting in 79 fatalities, 98 nonfatal injuries, and an aircraft dollar damage of \$17,060,490. Thus the majority of the orientation-error accidents involving Army Aviation aircraft occurred in RW aircraft in this fiscal year. As indicated by the RW data, the incidence and cost of accidents occurring in VN were both considerably greater than for accidents occurring elsewhere. This is particularly noticeable in the 11.00 to 1 VN/US fatal accident ratio, the 25.33 to 1 VN/US total fatality ratio, the 11.25 to 1 VN/US total injury ratio, and the 17.36 to 1 VN/US total dollar cost ratio.

The rate data in Figure 12 indicates that for FW aircraft, the over-all accident rates were 0.60 and 0.42 accidents per 100,000 hours and per 100,000 landings, respectively. For RW aircraft, the over-all rates were 1.42 and 0.43 accidents per 100,000 hours and per 100,000 landings, respectively. These rates, for both types of aircraft are about the same as those recorded for fiscal year 1969 (7).

COMPARATIVE INCIDENCE AND COST OF ORIENTATION-ERROR ACCIDENTS

The arrangement of the data presented in the previous sections was selected to differentiate the actual incidence and cost of all accidents, pilot-error accidents, and orientation-error accidents. In this section, selected incidence and cost data are expressed in percentage figures with the objective of gaining some insight into the relative contribution of orientation-error accidents to the over-all accident problem.

In Figure 13 the percent incidence of fatal accidents is described for all accident types, pilot-error accident types, and orientation-error accident types. The Figure 13A data show that for FW aircraft 10.44 percent of all FW accidents, regardless of accident cause of type, were fatal, with the incidence in VN being about 1.90 times the incidence in US. The RW data indicate that 17.41 percent of all RW accidents were fatal, with the VN incidence about 1.49 times the US incidence. In effect, considering all accidents, little difference exists in the percent incidence of fatal accidents relative to location for

TABLE IX FISCAL YEAR 1970 DATA ORIENTATION-ERROR ACCIDENTS ONLY				
			ALL AIRCRAFT	
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	18	63	81	3.50
Minor Accidents	0	0	0	---
Total Accidents	18	63	81	3.5
Total Dollar Cost	1,111,803	18,243,886	19,355,689	16.41
Average Dollar Cost per Accident	61,766.83	289,585.49	238,959.12	4.69
Total Fatalities	3	77	80	25.67
Average Fatalities per Accident	0.17	1.22	0.99	7.33
Fatal Accidents - Number	2	23	25	11.50
Fatal Accidents - Percent	11.11	36.51	30.87	3.29
Average Fatalities per Fatal Accident	1.50	3.35	3.20	2.23
Total Nonfatal Injuries	10	94	104	9.40
Average Nonfatal Injuries per Accident	0.56	1.49	1.28	2.69

TABLE X FISCAL YEAR 1970 DATA ORIENTATION-ERROR ACCIDENTS ONLY				
			FIXED WING AIRCRAFT	
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	2	4	6	2.00
Minor Accidents	0	0	0	---
Total Accidents	2	4	6	2.00
Total Dollar Cost	182,371	2,112,828	2,295,199	11.59
Average Dollar Cost per Accident	91,185.50	528,207.00	382,533.17	5.79
Total Fatalities	0	1	1	---
Average Fatalities per Accident	0.00	0.25	0.17	---
Fatal Accidents - Number	0	1	1	---
Fatal Accidents - Percent	0.00	25.00	16.67	---
Average Fatalities per Fatal Accident	0	1	1	---
Total Nonfatal Injuries	2	4	6	2.00
Average Nonfatal Injuries per Accident	1	1	1	1.00

TABLE XI FISCAL YEAR 1970 DATA ORIENTATION-ERROR ACCIDENTS ONLY				
ROTARY WING AIRCRAFT				
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	16	59	75	3.69
Minor Accidents	0	0	0	---
Total Accidents	16	59	75	3.69
Total Dollar Cost	929,432	16,131,058	17,060,490	17.36
Average Dollar Cost per Accident	58,089.50	273,407.76	227,473.20	4.71
Total Fatalities	3	76	79	25.33
Average Fatalities per Accident	0.19	1.29	1.05	6.87
Fatal Accidents - Number	2	22	24	11.00
Fatal Accidents - Percent	12.50	37.29	32.00	2.98
Average Fatalities per Fatal Accident	1.50	3.46	3.29	2.30
Total Nonfatal Injuries	8	90	98	11.25
Average Nonfatal Injuries per Accident	0.50	1.53	1.31	3.05

TABLE XII FISCAL YEAR 1970 DATA ORIENTATION-ERROR ACCIDENTS ONLY			
RATIO OF RW TO FW DATA			
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	8.00	14.75	12.50
Minor Accidents	---	---	---
Total Accidents	8.00	14.75	12.50
Total Dollar Cost	5.10	7.64	7.43
Average Dollar Cost per Accident	0.64	0.52	0.60
Total Fatalities	---	76.00	79.00
Average Fatalities per Accident	---	5.15	6.32
Fatal Accidents - Number	---	22.00	24.00
Fatal Accidents - Percent	---	1.49	1.92
Average Fatalities per Fatal Accident	---	3.46	3.29
Total Nonfatal Injuries	4.00	22.50	16.33
Average Nonfatal Injuries per Accident	0.50	1.53	1.31

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ORIENTATION - ERROR ACCIDENTS ONLY

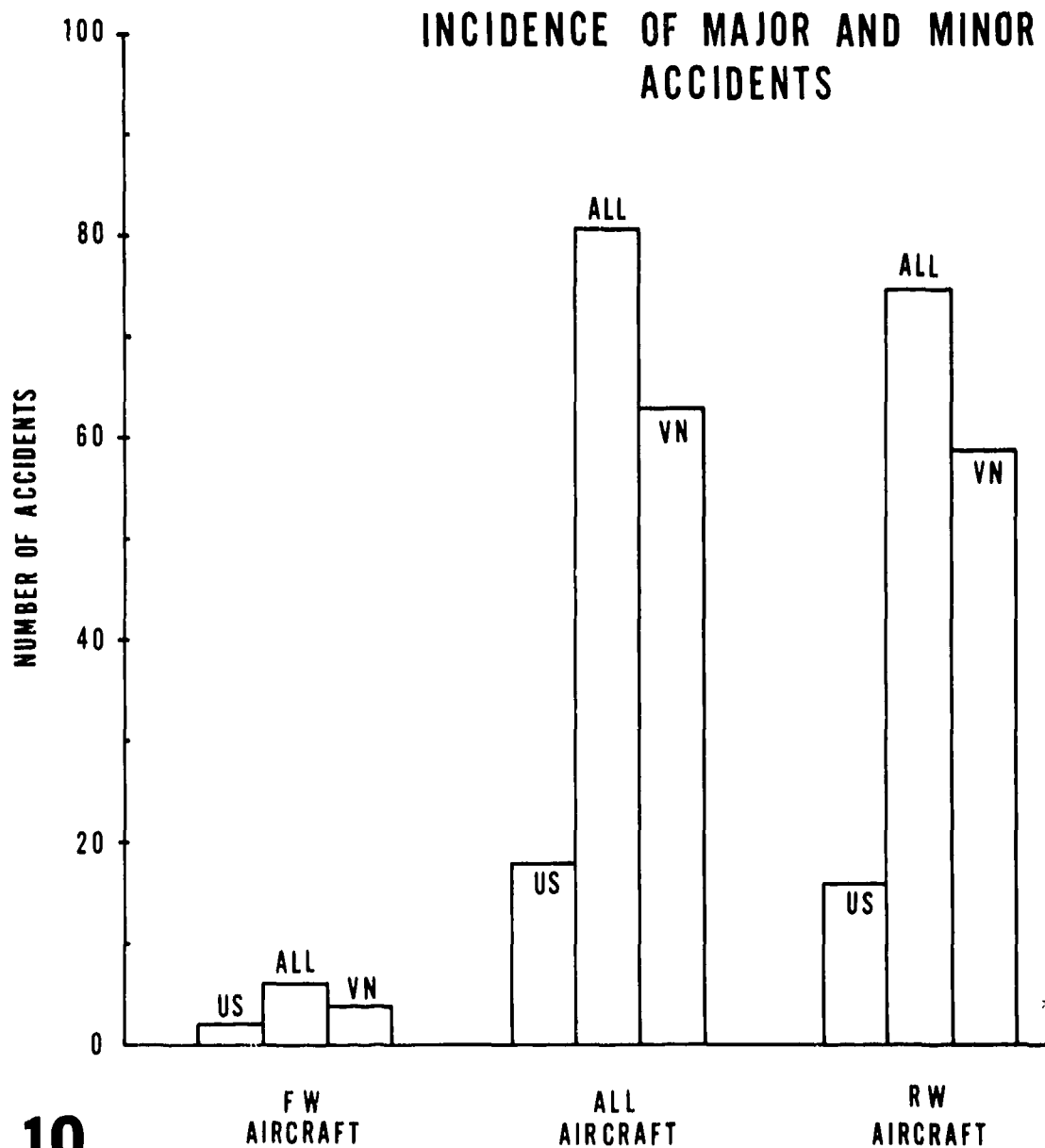


Figure 10

Orientation-Error Accident Types: Total number of major and minor orientation-error accidents located in the search of the USAAVS master accident files for fiscal year 1970. Considering all aircraft, the incidence of orientation-error accidents in VN was 3.50 times the incidence of similar accidents elsewhere. Note that the low incidence of FW accidents restricts the interpretation of VN/US or RW/FW relationships for this fiscal year.

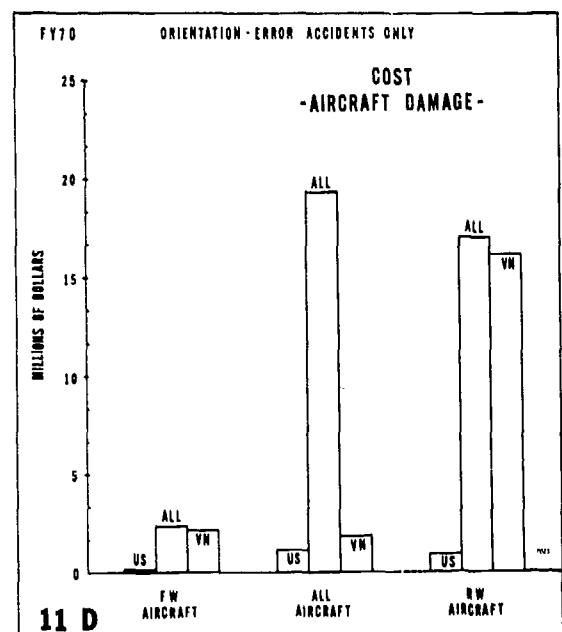
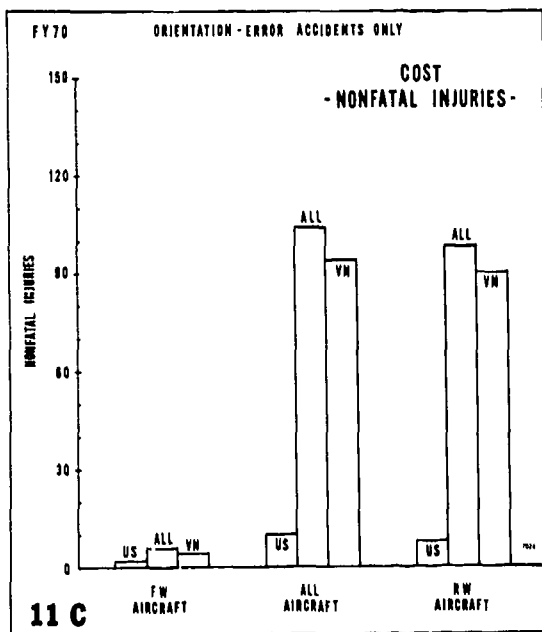
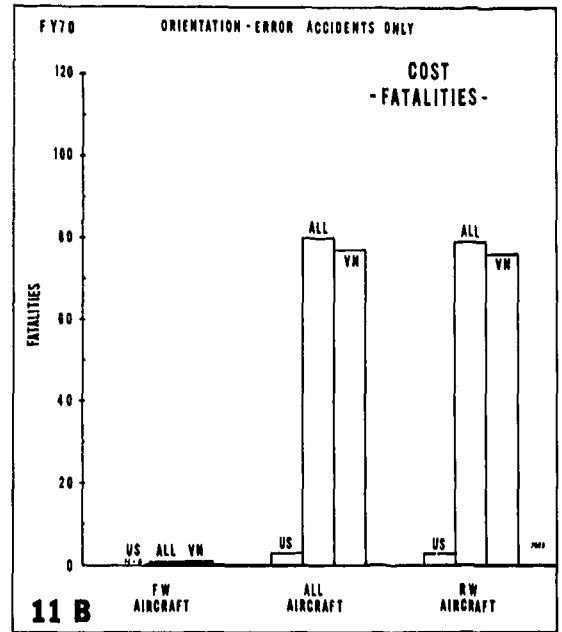
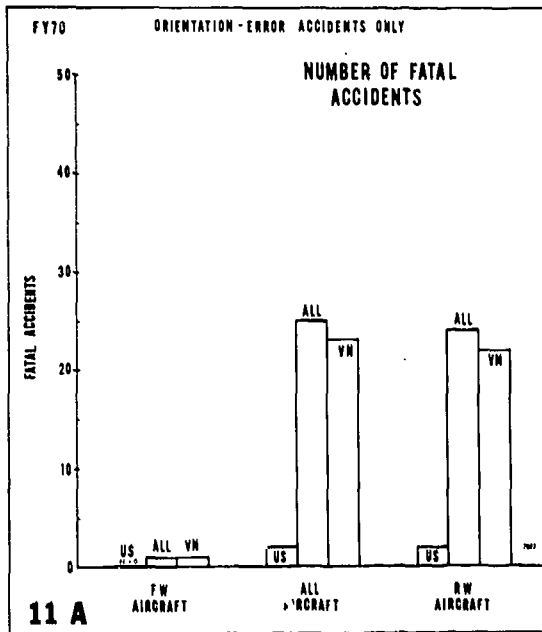


Figure 11

Orientation-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations. The reader is again alerted to the low n involved in the FW data. For RW aircraft, the loss was always greatest in VN.

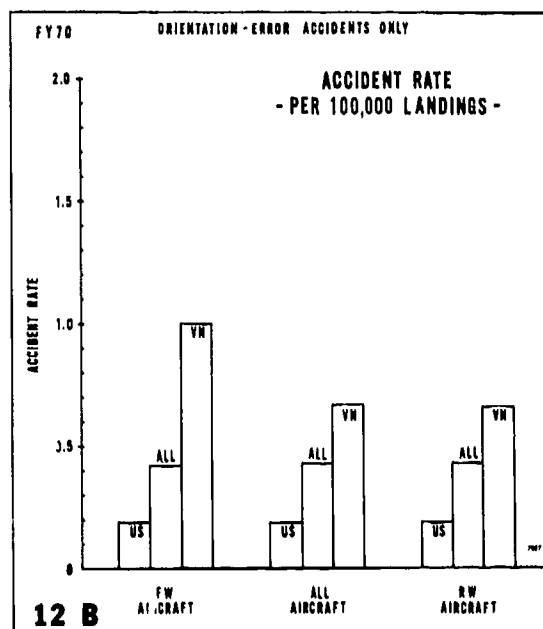
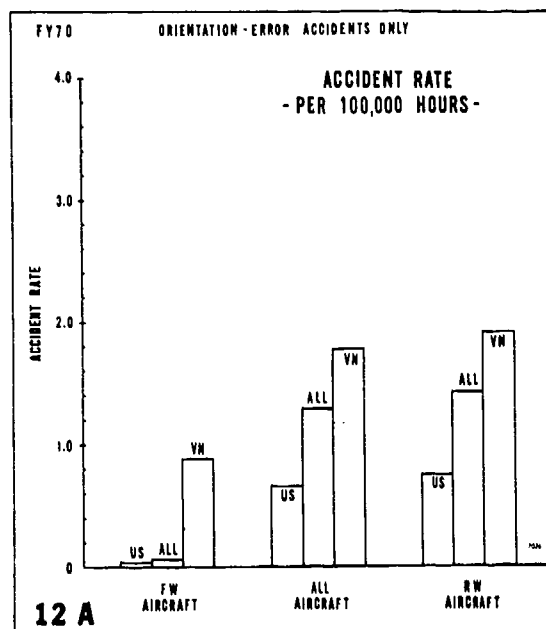


Figure 12

Orientation-Error Accident Types: Normalized incidence data showing average number of orientation-error accidents per 100,000 flying hours (A), and per 100,000 landings (B). These rate data are intended only as a fiscal year 1970 baseline reference for comparison with similar data calculated for other fiscal years of the longitudinal study. For all aircraft types, the over-all rates were 1.29 and 0.43 orientation-error accidents per 100,000 hours and per 100,000 landings, respectively.

either type of aircraft. Considering both aircraft types together, the totaled data of Figure 13A indicate 16.65 percent of all accidents were fatal.

The pilot-error accident data shown in Figure 13B indicates that the incidence of fatal accidents was 12.37 percent for FW aircraft, 18.65 percent for RW aircraft, and 17.89 percent for their combined sum. The VN/US fatal accident percent incidence ratio for RW aircraft was 1.58 to 1 as compared to a FW ratio of 1.80 to 1.

For orientation-error accidents, however, the probability of a fatal accident was much higher, as shown in Figure 13C. Again, the reader is cautioned to remember the low incidence of FW accidents for this period. Since neither accident that occurred in the US was fatal, this accounts for the 0 percent datum in Figure 13C. Thus for fiscal year 1970, the relative incidence and cost of orientation-error accidents derived predominantly from RW accidents. In the remaining orientation-error figures then, the "All-Aircraft" data will, in essence, be identical to the "RW Aircraft" data. The percent incidence of fatal accidents when orientation error was involved rose to 36.51 percent in VN and 11.11 percent in the US.

Similar comparisons for the three classes of accidents are made in Figure 14 for the average number of fatalities per fatal accident. In this case, for all aircraft, the cost of orientation-error accidents was about that calculated for the other two classes of accidents. However, the orientation-error accident cost in VN exceeded that occurring in the US, as it did for the all-accident and pilot-error accident data for all aircraft types. The same format is used in Figure 15 to depict the average number of nonfatal injuries that occurred per accident. The all aircraft data indicate a more or less comparable cost for all three accident classifications. However, for orientation-error accidents, the VN/US ratio was somewhat greater than that of the other two accident classifications. In terms of the average dollar cost data presented in Figure 16, orientation-error accidents resulted in the greatest loss.

Figures 17 through 20 illustrate the relative contribution of orientation-error accidents in all aircraft types to selected incidence and cost data as a given percentage of corresponding statistics for both "all accident types" and "pilot-error accident types." In Figure 17, orientation-error accidents can be seen to represent 7.66 percent of all accidents that occurred during this year and 10.06 percent of all pilot-error accidents. When one considers the number of fatal accidents that occurred in the two accident groups, as is done in Figure 18, orientation-error fatal accidents represent 14.21 percent of all fatal accidents and 17.36 percent of all fatal pilot-error accidents. In terms of fatalities, orientation-error accidents resulted in 15.45 percent of the total number and 19.37 percent of those occurring in pilot-error accidents, as indicated in Figure 19. Lastly, orientation-error accidents accounted for over 12.35 percent of the total cost of all accidents and 16.36 percent of the cost of all pilot-error accidents, as shown in Figure 20.

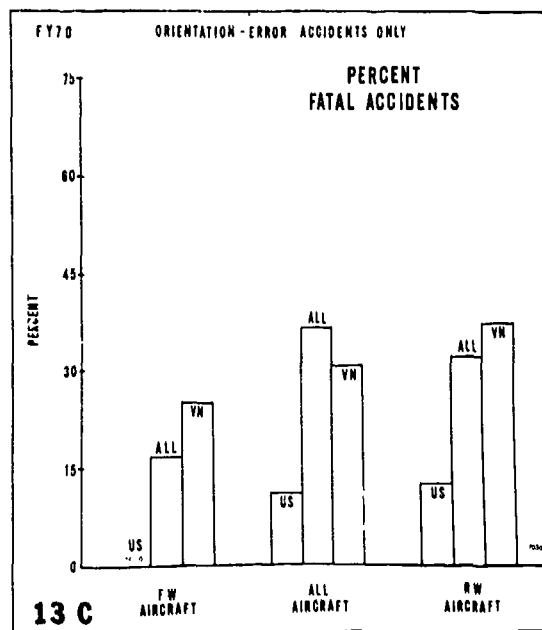
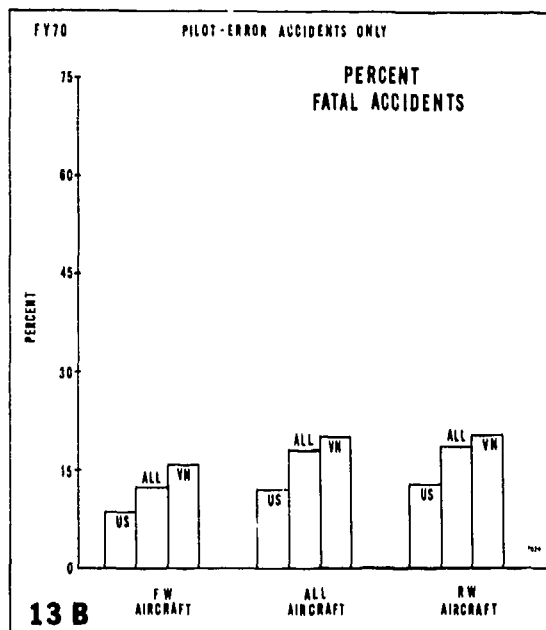
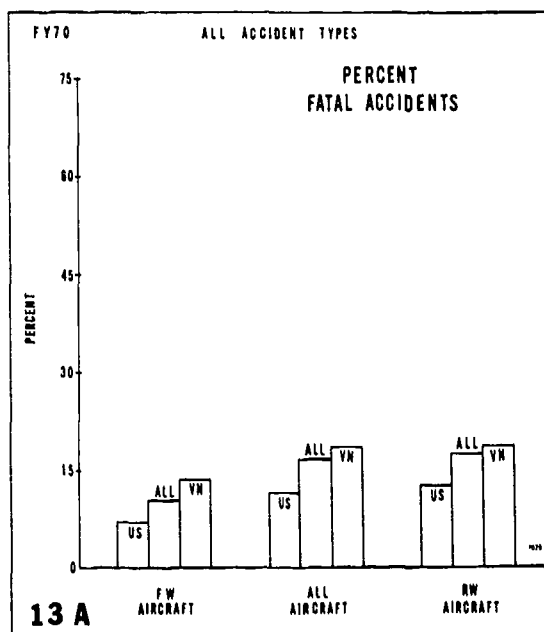


Figure 13

Comparative incidence of fatal accidents expressed as the percent of the total number of accidents within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications that resulted in one or more fatalities. Note that orientation-error accidents had a significantly higher percentage of fatal accidents.

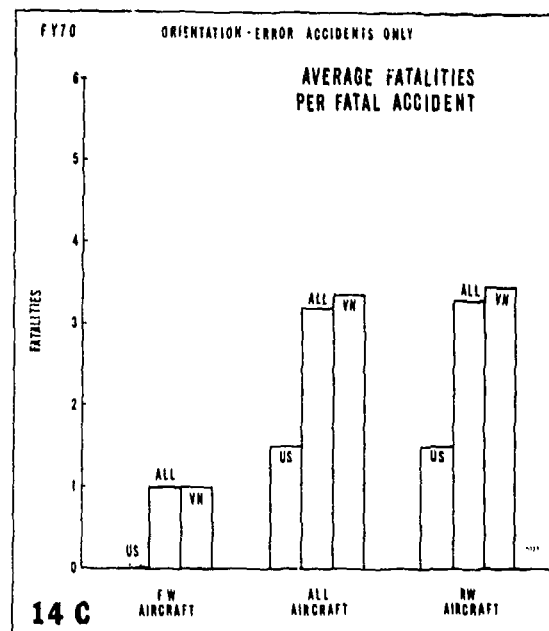
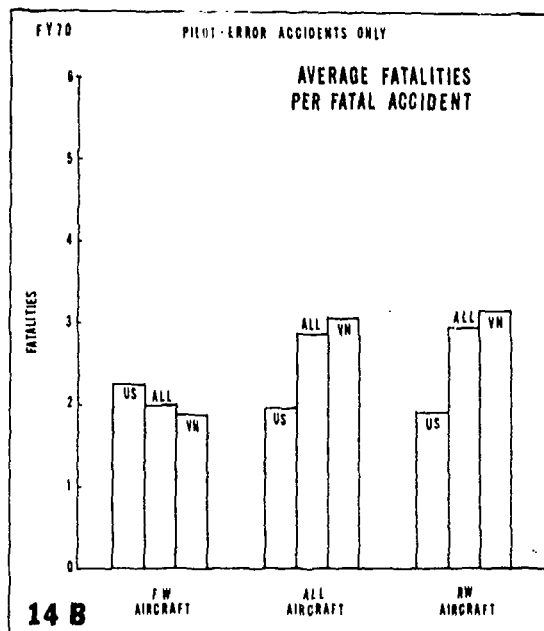
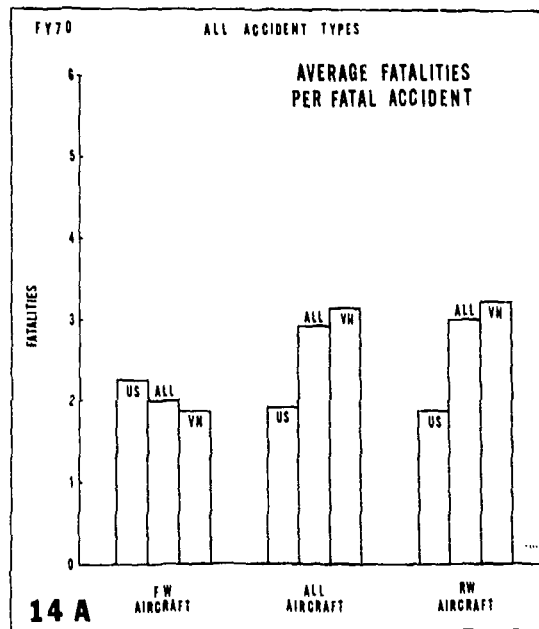


Figure 14

Average number of fatalities per fatal accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

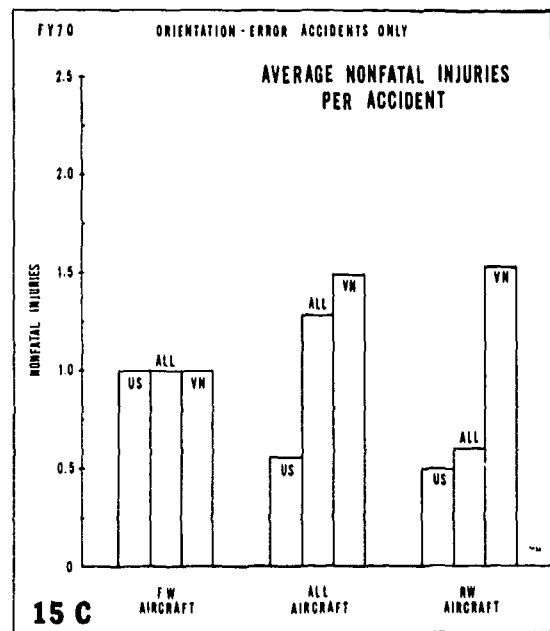
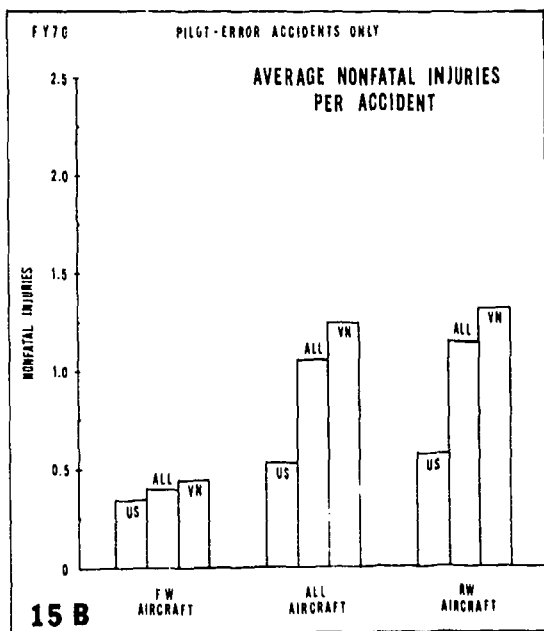
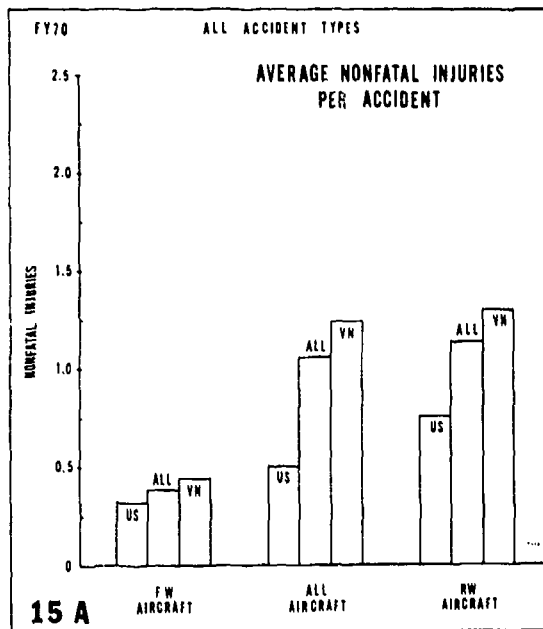


Figure 15

Average number of nonfatal injuries per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

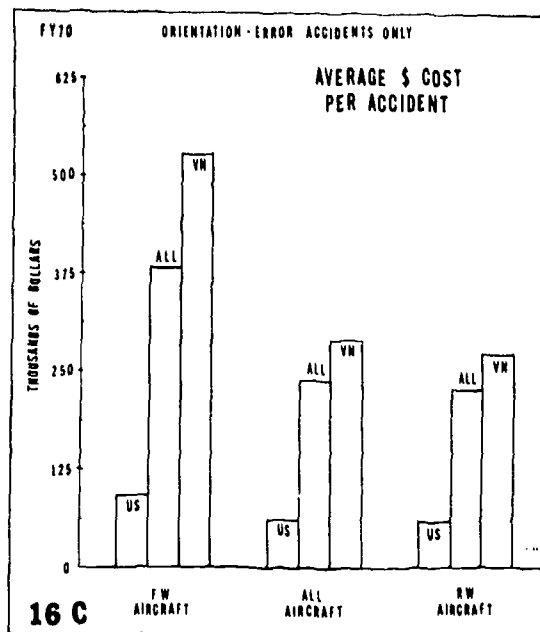
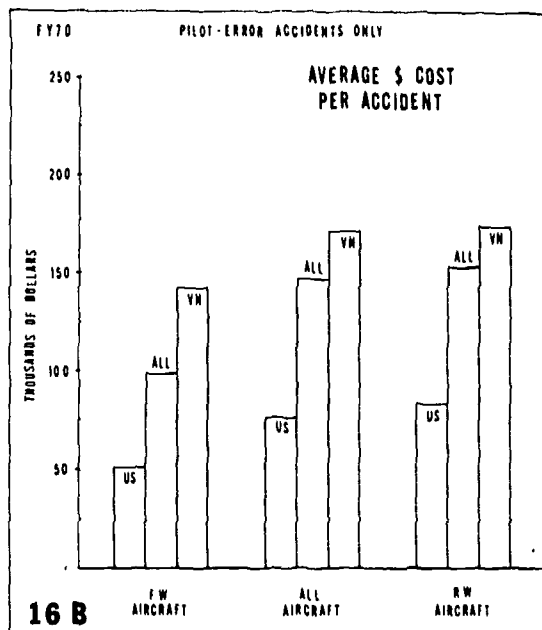
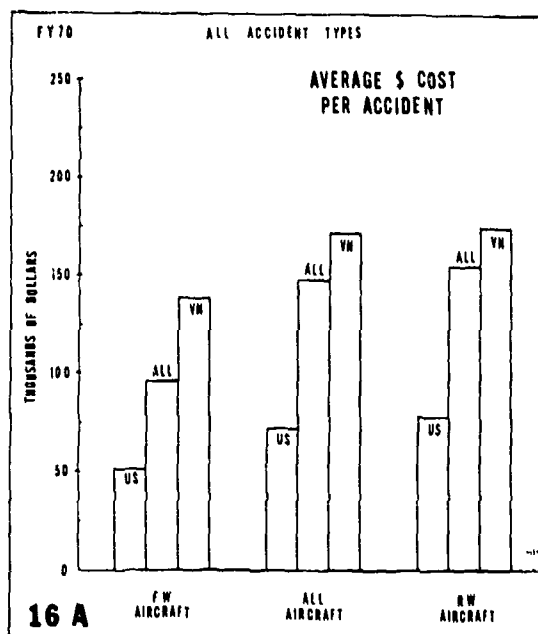


Figure 16

Average aircraft dollar damage per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications. The average cost was greatest for orientation-error accidents.

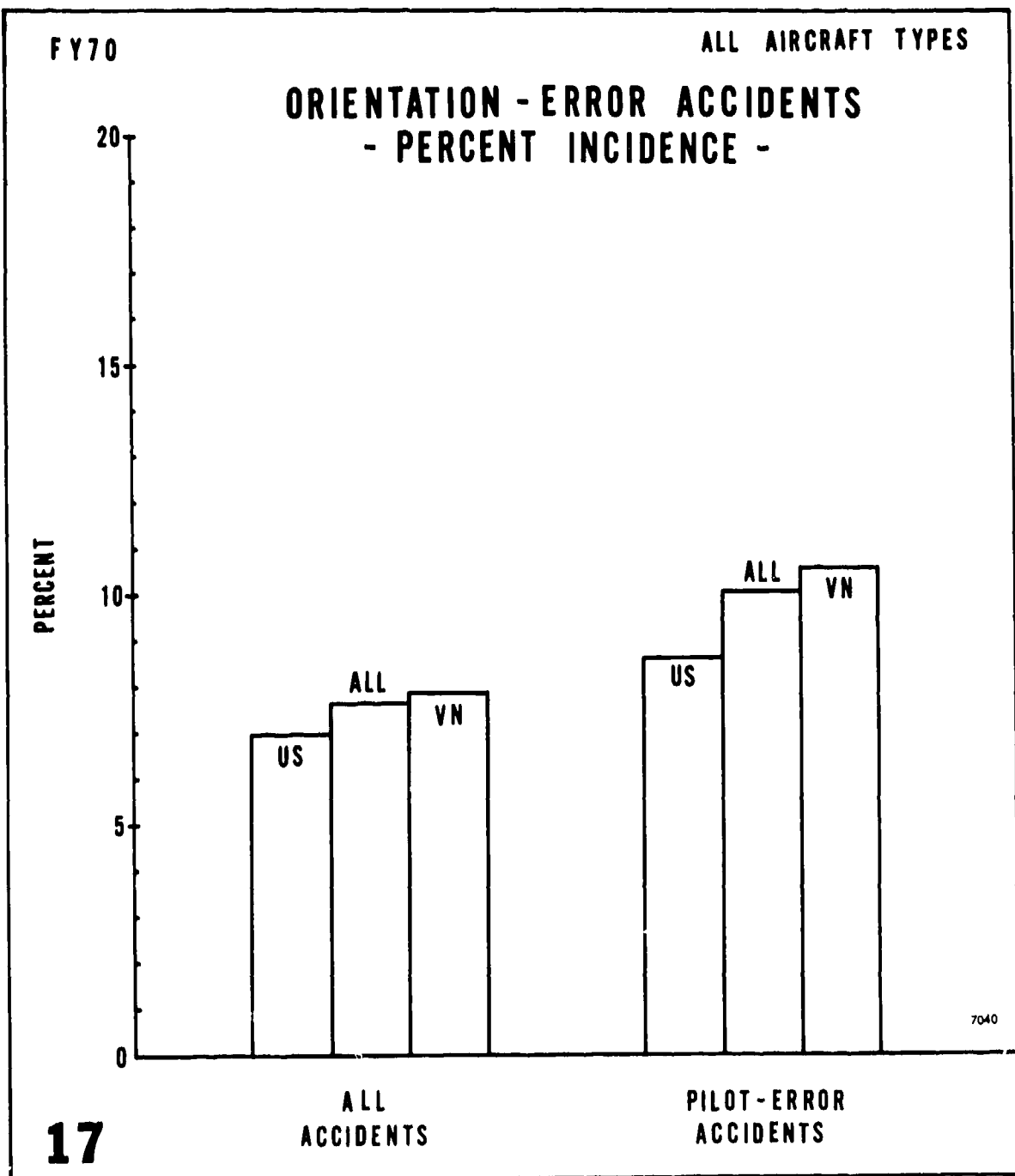


Figure 17

Percent contribution of all orientation-error accidents to the total number of accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Considering all types of aircraft, orientation-error accidents accounted for 7.66 percent of all accidents and 10.06 percent of all pilot-error accidents.

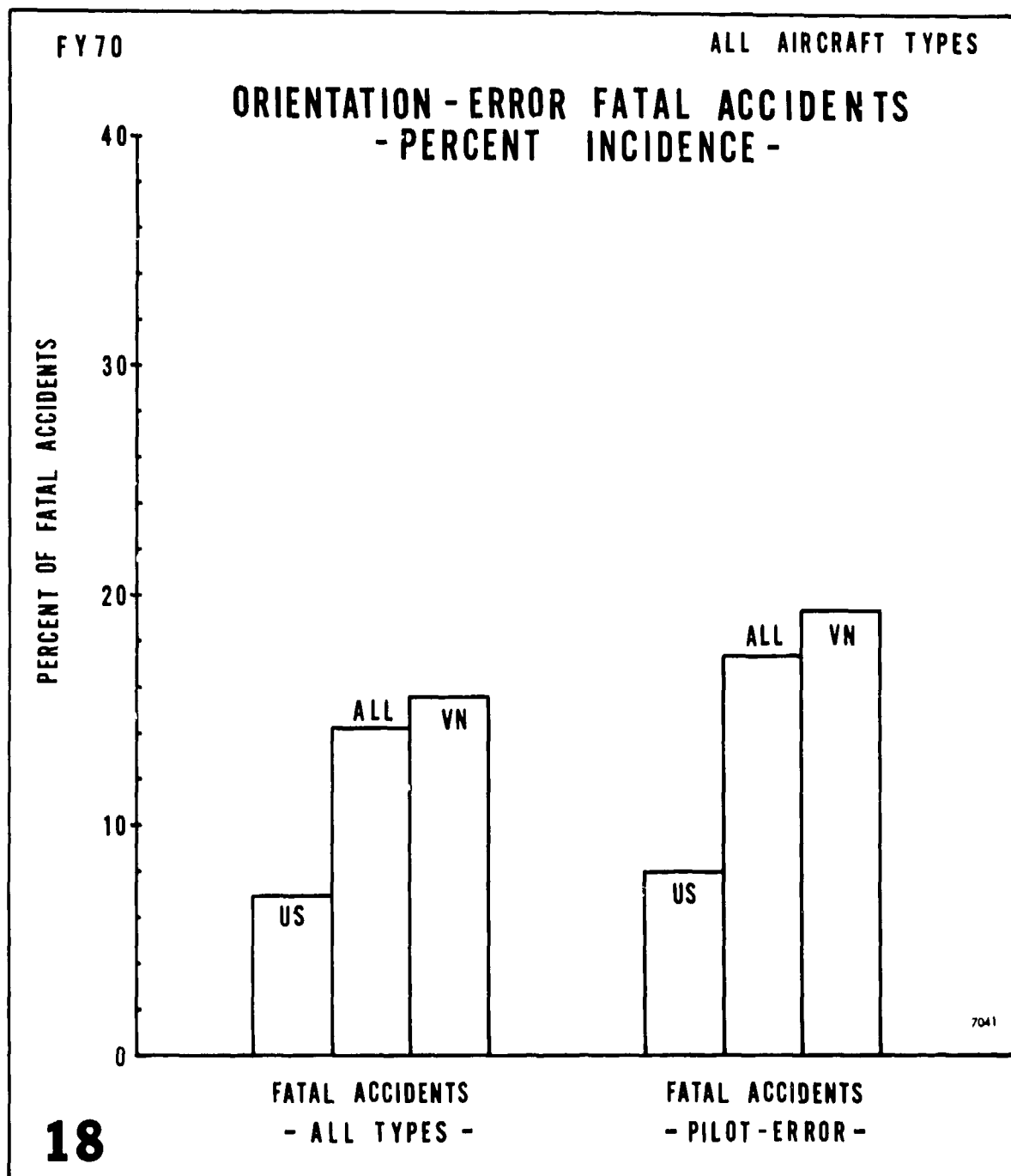


Figure 18

Percent contribution of all fatal orientation-error accidents to the total number of fatal accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 14.21 percent of all fatal accidents and 17.36 percent of all fatal pilot-error accidents.

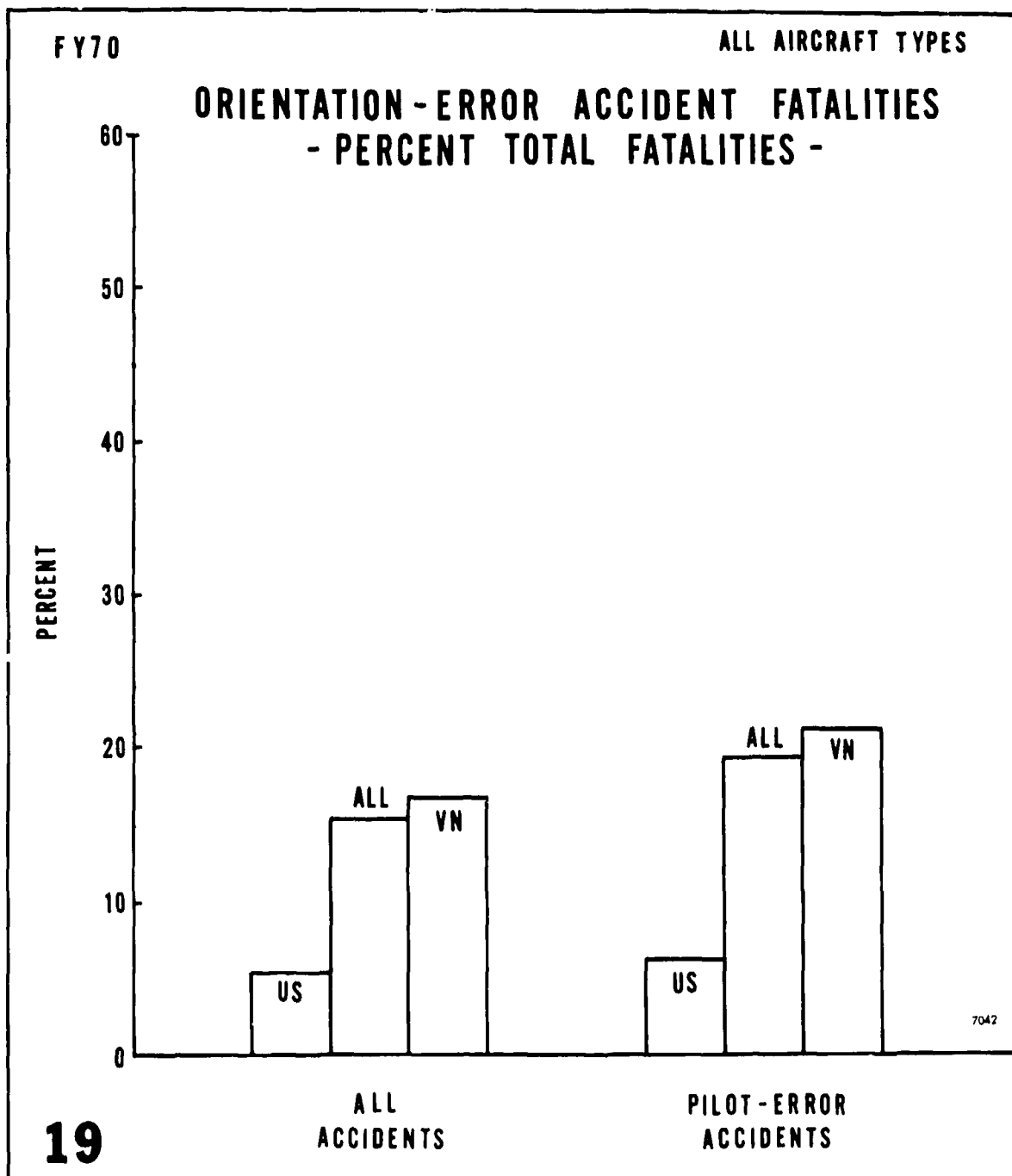


Figure 19

Percent contribution of all orientation-error accident fatalities to the total number of fatalities occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 15.45 percent of the total number of fatalities and 19.37 percent of the fatalities due to pilot-error accidents.

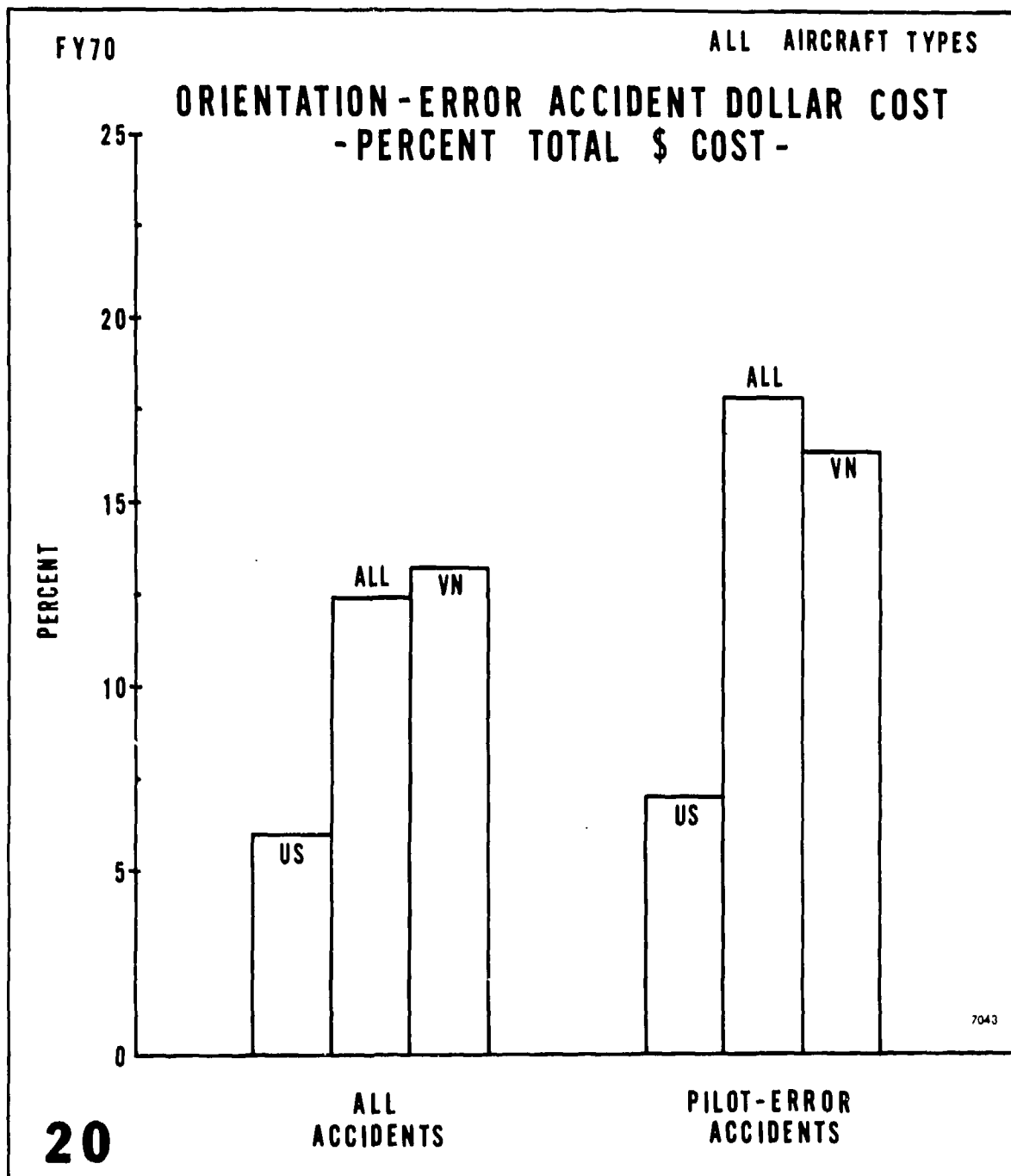


Figure 20

Percent contribution of the dollar cost of all orientation-error accidents to the total cost of all accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 12.35 percent of the total cost of all accidents and 16.36 percent of the cost of all pilot-error accidents.

At this time, no attempt will be made to discuss further these findings or to draw any conclusions as to their over-all significance. Since corresponding data are under preparation for subsequent fiscal years, the full significance of the fiscal year 1970 data will depend upon whether this longitudinal analysis does or does not establish the presence of consistencies or trends in the accident experiences. Moreover, it is the function of this element of the longitudinal study only to provide quantitative data; the actual evaluation of the accident in terms of effect on the military mission must remain with those responsible for the direction of military aviation operations.

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